Chronology of the Current Spruce Beetle Infestation on the Payette National Forest, Idaho

R. W. Thier[1]

ABSTRACT. Spruce trees on the Payette National Forest sustained an unprecedented infestation of spruce beetle since the early 1980's which continues today. To date, over 350,000 trees have been infested and killed. Despite valliant management efforts by forest managers, the infestation will run its course similar to prior infestations and probably like those of the future in spruce forests of North America. The ecological and administrative results of this infestation will be significant long into the future. A chronological description of the infestation and management actions are reported.

INTRODUCTION

The spruce beetle, *Dendroctonus rufipennis (Kirby)*, is the most prevelent mortality agent of all species of mature spruce in North America. Extensive outbreaks have occurred from Alaska, in the north, to Arizona, in the south, wherever extensive stands of spruce exist (Holsten et al. 1991).

Many spruce beetle infestations have been reported over the last 100 years. Spruce stands in Colorado, New Mexico, Alaska and British Columbia have sustained repeated severe mortality ranging from 50% to 90% of the trees. Schmid and Frye (1977) document most of the important infestations.

Extensive infestations, where millions of trees are killed, influence the forest ecosystem in many ways. Not only is the forest structure directly changed by reducing average tree age, diameter, height and stand density but changes also affect wildlife, water yield, fire hazard and forest succession (Holsten et al. 1991, Schmid and Amman 1992, Schmid and Frye 1977).

Mocettini and Cahill (1989) documented past spruce beetle infestations on the Payette National Forest. The first infestation they mention occurred from 1947 to 1950 where over 2,000 infested trees were tallied in a survey of 9,000 acres. In 1958 and 1959 another 2,000 trees were killed. From 1965 through 1971 four other infestations occurred.

None of the previous documented infestations on the Payette National Forest compare to the current outbreak which started in 1981 and 1982 and continues today. Since 1984 spruce beetle has killed over 350,000 trees over 186,000 acres according to aerial surveys. Despite valliant efforts to manage the infestation it will run its course and cause long term ecological and administrative effects.

The objective of this report is to summarize the important events of the last ten years regarding this spruce beetle infestation on the Payette National Forest. Where possible I have addressed biological, administrative and experimental aspects of the infestation by year. This report will hopefully provide land managers with some guidance when the next insect infestation arises.

LIFE HISTORY - HABITS

Spruce beetle is native to spruce stands of North America, hence; it has coevolved with its host. Its life cycle and behavior reflect the life strategies necessary for survival. Biology is discussed in detail by Schmid and Frye (1977).

Life Cycle and Evidence of Infestation

Spruce beetle development and survival is dependent on temperature which affects the length of the life cycle. Although a 2-year life cycle is most common, beetles may fully develop in 1-year, given warm conditions, or necessitate 3 to 4 years to develop where conditions are cool on shaded north slopes.

---

[1]Entomologist, Forest Pest Management, Intermountain Region, USDA Forest Service.

LIBRARY COPY
ROCKY MT. FOREST & RANGE
EXPERIMENT STATION

In the 2-year cycle adult beetles usually attack in early summer but, again, their activity is based on local temperatures. Eggs soon hatch following deposition and the larvae overwinter. The following spring larval development continues and pupation occurs approximately one year after attack. The second winter is passed as new adults before emergence the next summer to attack host material and complete the life cycle.

In the 1-year life cycle the entire development process is accelerated. Given the appropriate temperatures, beetles go from egg to new adult in one summer season. They overwinter once, as adults, and emerge to attack host material one year after egg deposition.

Foliage of the infested tree usually does not begin to fade, gradually changing from green to brown, until one year following attack. Therefore, when an infestation is detected because of the changing color of the trees' foliage, the beetles' development is already well underway.

Habits

A portion of new adults in the 2-year life cycle emerge in late fall and move to the bases of trees where they reenter to overwinter. This is evidently a survival mechanism in response to cold winter temperatures and predation above snowline (Schmid and Frye 1977). The basal portion of the tree will usually be covered in snow in winter. The snow moderates the temperatures and protects the adults from predation by woodpeckers. This overwintering behavior only occurs in standing trees. In windthrown trees the adults overwinter in their pupation cells. Schmid and Frye (1977) discuss hibernation in detail.

The spruce beetle prefers certain host trees probably because they are more conducive to beetle survival (Schmid and Frye 1977). Downed trees are preferred to standing trees. Most outbreaks in standing trees originate from infestations in windthrown trees (Holsten et al. 1991). After downed trees the beetle prefers large diamter standing trees. Typically, the largest diameter trees are attacked first. If the infestation persists, smaller diameter trees are attacked each year (Holsten et al. 1991) until only non-host trees and spruces under 10" in diameter remain. Mocettini and Cahill (1989) and Mocettini (1991) document spruce beetle caused changes in stand compostion for the period 1985 to 1990 on the Payette National Forest.

The mass attack of a tree is an important behavior common to may species of bark beetles. Mass attack ensures species survival by aggregating insects to overcome the defenses of the host tree and improve the chances of mating. Mass attack for spruce beetle, like other species of bark beetles, is pheromone induced (Dyer and Chapman 1971).

The behavior of anti-aggregation is also found in many bark beetles. This behavior causes beetles to be repelled from a recently attacked tree opposite to that of aggregation during mass attack. Anti-aggregation, like mass attack, is pheromone induced and prevents the over colonization of a tree by beetles to mediate effects of larval competiton.

Summary

An understanding of the life cycle and habits is important. Life cycle and habits form the bases for the management options employed and events which occurred over the course of the spruce beetle infestation on the Payette National Forest.

MANAGEMENT OPTIONS EMPLOYED IN THE CURRENT INFESTATION

Various strategies are available when considering pest management. The following options can be included under cultural, chemical, biological or integrated management strategies. These strategies are based on an understanding of the beetle's biology.

Cultural Strategy

The cultural strategy involves tree harvest or manipulation of stands to limit infestation or concentrate beetles. The effects can be both short- and long-term depending on design of the option. Some options under this strategy employed during this infestation include:

Salvage -

Smith (1962) defines salvage cuttings - "Salvage cuttings are made for the primary purpose of removing trees that have been or are in imminent danger of being killed or damaged by injurious agencies other than competition between trees." Salvage of windthrown or snow-broken trees prior to beetle colonization, or after colonization but before brood maturation, can mitigate an outbreak (Schmid and Frye 1977). Likewise salvage of infested standing trees is often employed to remove beetles before the brood matures. Material removed via salvage cuttings is generally utilized as timber; therefore, beetle management via salvage is usually economically desireable but often limited by environmental situations regarding its practice.

Trap Trees -

Nagel et al. (1957) discuss various aspects of trap tree use for spruce beetle management. Trap trees for spruce beetle are large diameter uninfested spruces that are felled soon before beetle flight. They simulate windthrown trees, which the beetles prefer, thus decoying beetles away from standing trees. After beetle flight and trap tree colonization, but before brood maturation, the trap tree must be treated to either kill the brood or remove them from the forest. Several means of treatment follow:

- *removal* - Occupied trap trees are sold for timber and removed to the mill before the brood matures. This is economically desireable because timber values can be recovered.

- *burning* - The brood occupying the trap tree is killed by burning the infested material. Only the bark needs to be scorched to destroy the brood (Holsten et al. 1991).

- *solar dry* - "The solar-heat method of bark-beetle control consists primarily in utilizing direct sunlight to kill broods of beetles in the inner bark of thin-bark trees..." (Patterson 1930). Thus infested trap trees can be exposed to direct sunlight to kill the brood. Holsten et al. (1991) recommended rotating the material every 2 weeks to expose all surfaces.

- *peeling* - Any means which prevents brood maturation in the trap tree prevents further population buildup. Physical removal of the tree's bark exposes larvae and destroys the brood.

Chemical Strategy

The chemical strategy has limited scope for use only in short-term applications. Insecticides are used to kill insects either where they may attack or have attacked trees. Two options under this strategy used during this infestation include:

Lethal Trap Trees -

Traditionally lethal trap trees are trap trees which have been first injected with a silvicide (Holsten et al. 1991). The silvicide has proven to be toxic to the developing brood. Lethal trap trees employed during this infestation used insecticides, rather than a silvicide, to achieve similar results.

Protective Sprays -

Insecticides can be applied to boles of uninfested trees to kill attacking beetles (Holsten et al. 1991). The insecticide protects the tree and is most applicable around developed sites where the trees are highly valued. The sprays only provide short-term protection.

Biological Strategy

The biological management strategy seeks long-term effects on the target population by introducing or augmenting antagonistic or controlling agents which are routinely found in the environment. The strategy is best used on non-native organisms by introduction of their predators and parasites. Because pheromones are part of the beetle's biology, I chose to include pheromone based management options under the biological management strategy. Two pheromone based options were part of the spruce beetle management actions.

Pheromone Bait and Treat -

Some spruce beetle aggregation pheromones have been identified and synthesized. These synthesized pheromones can therefore be used to bait beetles - attracting them into standing or downed uninfested host trees. Once the trees are colonized the trees must be treated as trap trees discussed previously. Schmid and Frye (1977) and Shore et al. (1990) discuss the option.

Anti-aggregation Pheromone - MCH -

MCH (3-methyl-2-cyclohexen-1-one), the natural anti-aggregation pheromone of Douglas-fir beetle (*D. pseudosugae* Hopkins), represses spruce beetle attacks (Kline et al. 1974). The material, generally released from plastic dispensers, could potentially be used to provide short-term protection from spruce beetle attacks.

Integrated Strategy

All aspects are considered and various management options employed in the integrated strategy. The focus is both long- and short-term. An integrated strategy is often complex but complete in that several aspects of the pest population are manipulated simultaneously to achieve rapid but long-lasting pest management objectives. Because spruce beetle management on the Payette National Forest involved cultural, chemical and biological strategies one can state that the management effort was, in fact, integrated.

CHRONOLOGY OF THE CURRENT INFESTATION

1981-1982

From fall 1981 through spring 1982 scattered areas of Englemann spruce were windthrown over the Payette National Forest. Many areas experienced windthrow but followup evaluations detected beetles in only a few sites. Windthrown areas where no beetles were found included: Boulder Creek, Middle Fork Weiser River, Bear Creek, Threemile Creek, Hendricks Creek and War Eagle Mountain. Some beetles were found in windthrown spruce at: Rapid River, Sinking Creek, Corduroy Creek, Cloochman Creek, Granite Lake and East Fork Fisher Creek. Finally large populations of spruce beetle had colonized windthrow in: Outlet Creek, Fisher Creek, Twentymile Creek and Hazard Lake (figure 1).

1983-1984

Salvage of the heavily infested windthrown trees was begun around Scribner Lake, Corduroy Creek, Threemile Creek and California Lake. Another spruce timber sale was in progress at Corral Creek.

More windthrown spruce spruce was found concentrated in one-half to 5 acre parcels in Pearl Creek, Poorman Creek, Pony Creek, Lake Creek, Wilson Creek, Jackson Creek, Josephine Creek, Brush Creek, Wetfoot Creek, Sand Creek, Willow Creek, Trail Creek, Pond Creek and Wagon Bay Creek (figure 2). Only a few infested trees were noted.

1985

Aerial detection surveys tallied over 2,600 trees killed by spruce beetle. Approximately 160 centers of beetle mortality were identified. They were generally located between the Little Salmon River and the North Fork Payette River (figure 3).

Forest managers responded to the infestation by:

- salvage of approximately 8.9 million board feet of spruce in the roaded portion of the Payette National Forest from lands identified as commercial spruce timber (USDA Forest Service Payette National Forest 1986).

Figure 1. Area map of Payette National Forest, Idaho, 1981-1982.

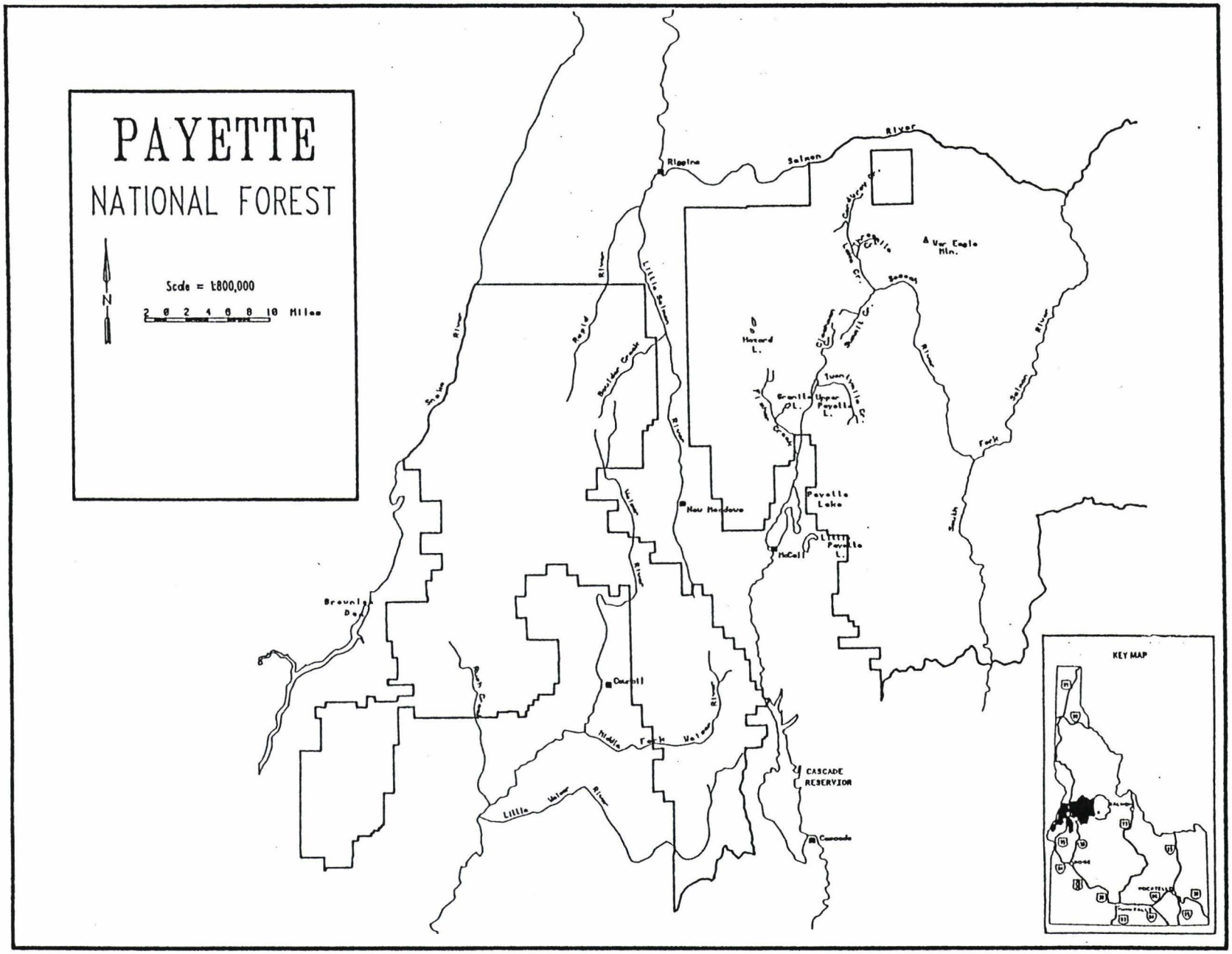


Figure 2. Area map of Payette National Forest, Idaho, 1983-1984.

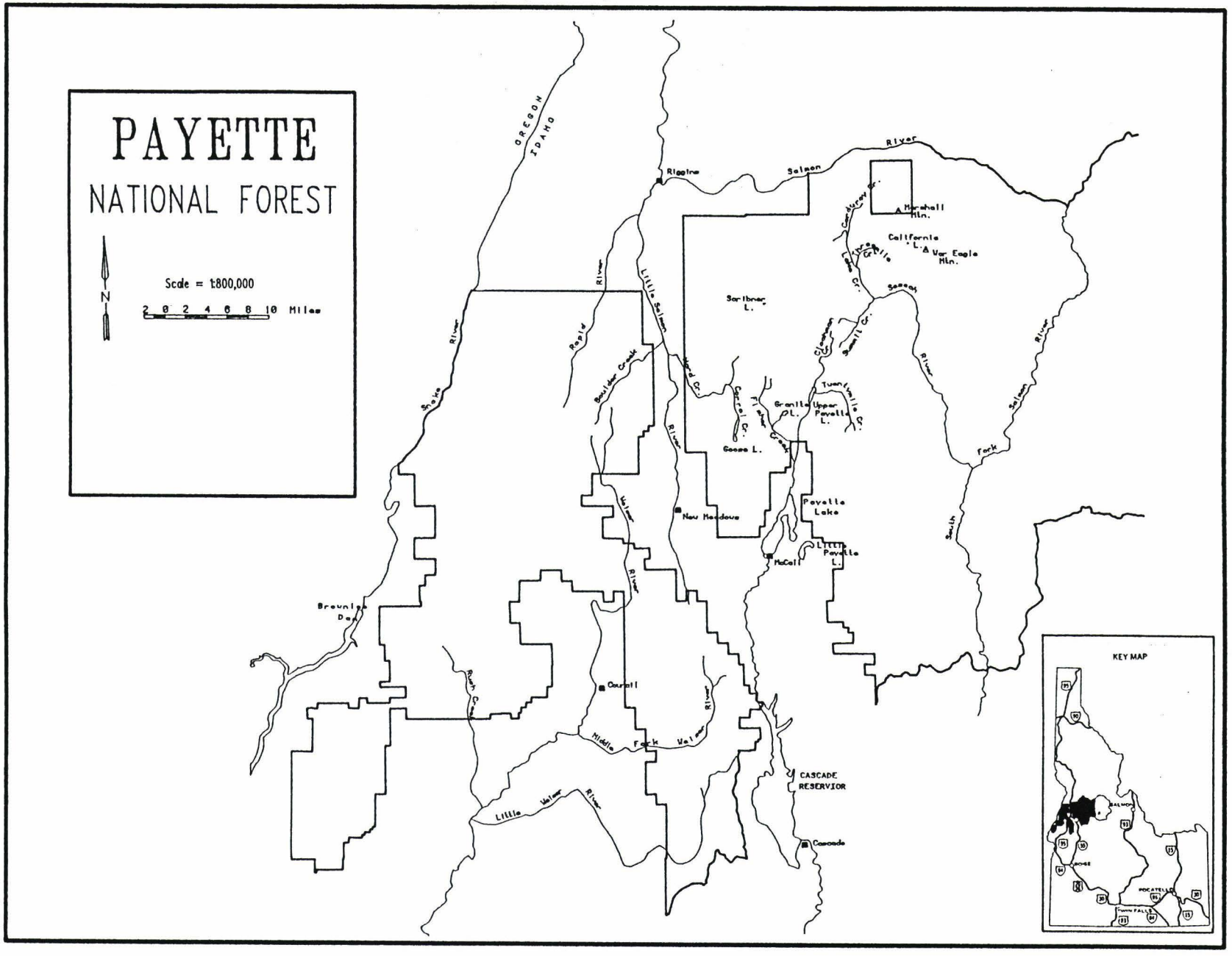
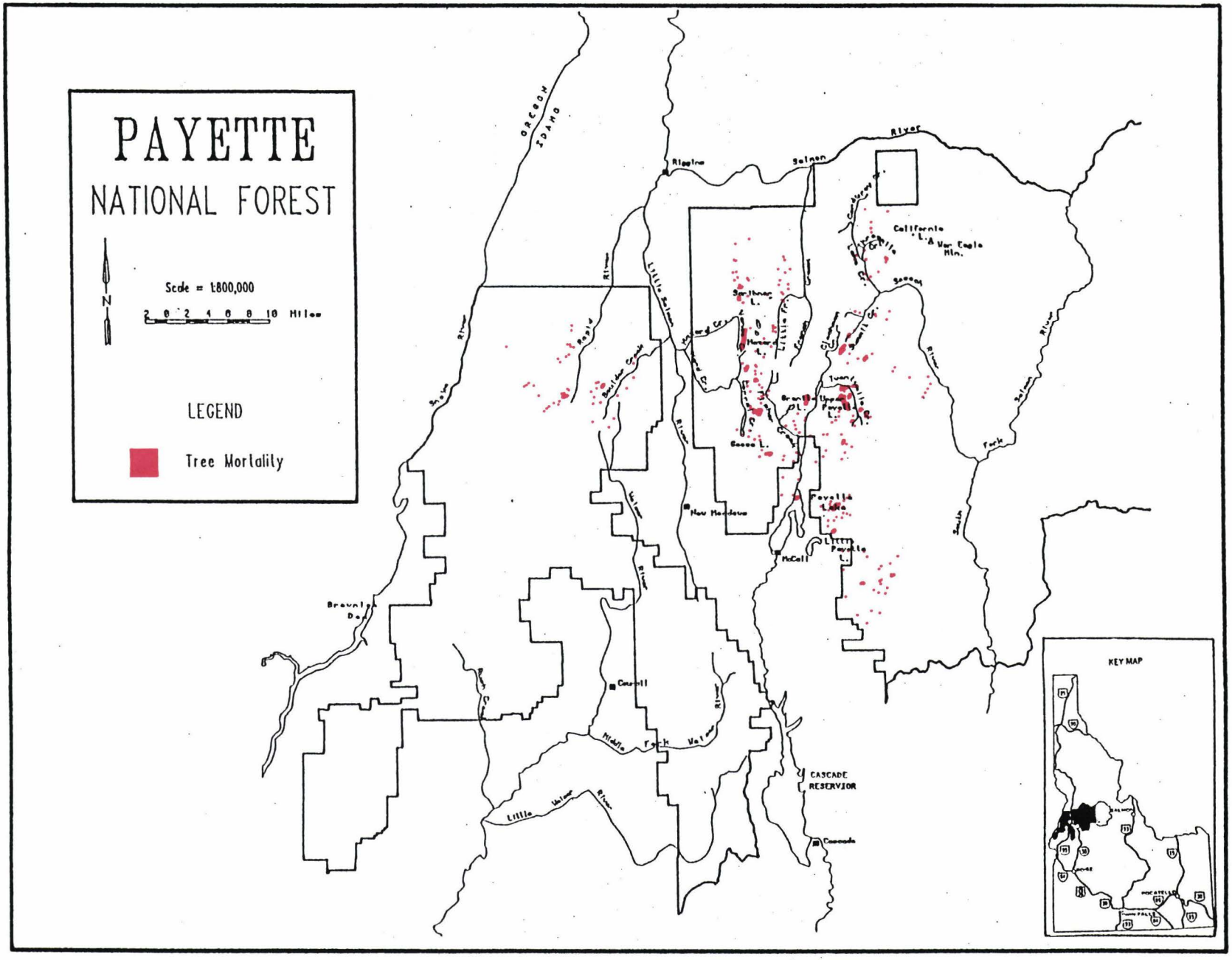


Figure 3. Trees killed by spruce beetle according to aerial detection survey, Payette National Forest, Idaho 1985.



- initiating an environmental assessment of management alternatives to limit further infestation on the lands identified as commercial spruce timber. These actions became known as the "Spruce Beetle Containment Project" (USDA Forest Service Payette National Forest 1986).
- requesting additional funds to augment and implement further spruce beetle management options.

1986

Aerial detection surveys identified over 900 centers of infestation where approximately 12,600 spruce trees were killed. The infestation was generally located in an area bounded by Vance Creek and Corral Creek on the west to Twentymile Creek on the east and Payette Lake on the south to War Eagle and Marshall Mountains in the north (figure 4).

Forest managers continued the efforts begun in 1985. Over 10 million board feet of spruce was salvaged. Work continued on the environmental assessment which was finalized and a decision issued in May 1986.

The environmental assessment deserves further comment since forest managers implemented the project from 1986 to 1989. I have taken the following quotes from the Forest Supervisor's decision:

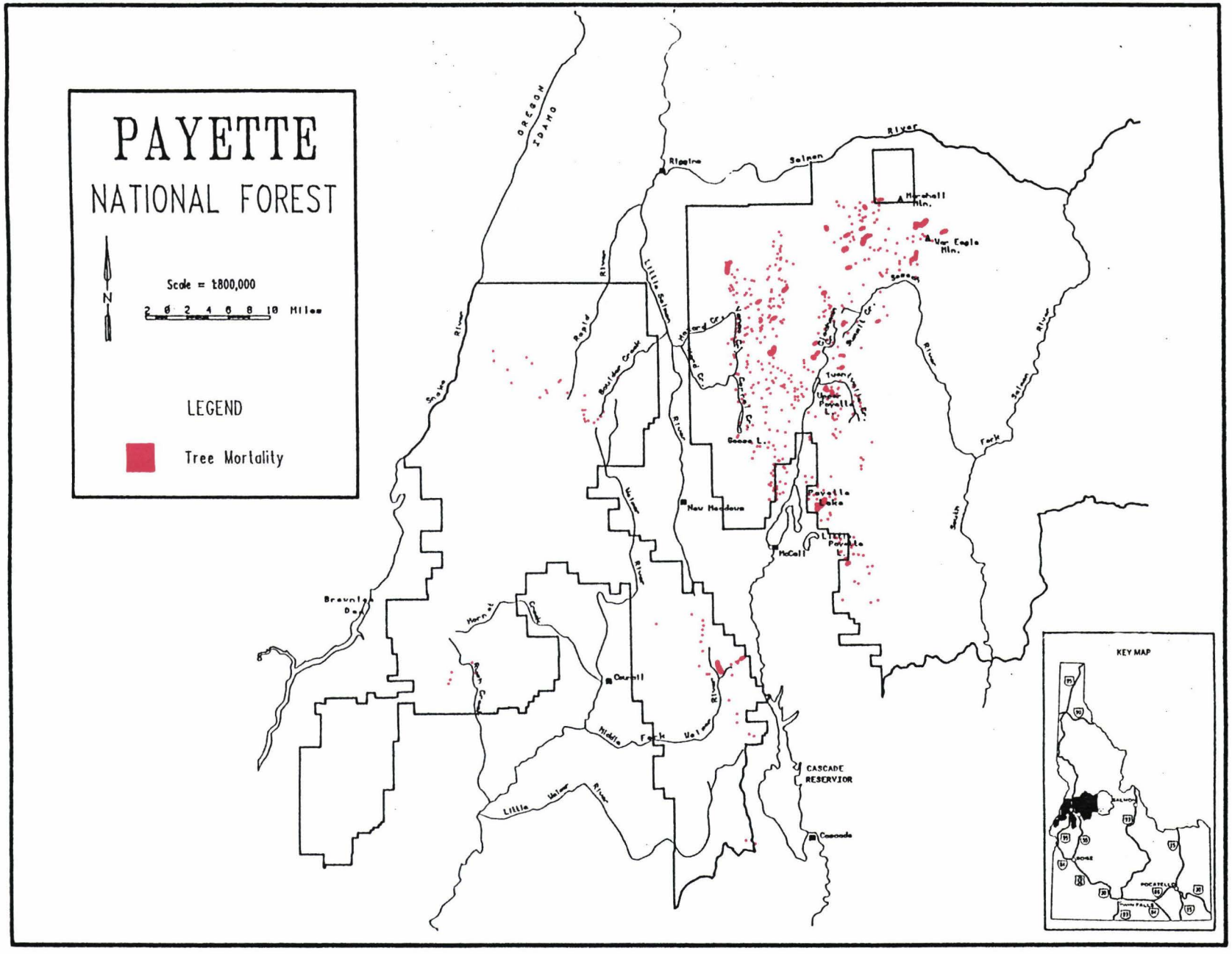
> "...I consider the nature of this proposal to be an emergency due to the need to promptly initiate control or containment activities of the spruce beetle epidemic. ...Implementation of this project will result in limited containment of the spruce beetle...The objective of the containment activity is to protect the commercial spruce timber base, in addition to other resource values, from impacts resulting from infestation by the current spruce beetle outbreak. The objective is not to control all outbreaks, only those which are a threat to the commercial timber base. Nor is the objective to permit the salvage of diseased and dead trees other than the trap trees themselves. ...My proposal calls for treating approximately 2000 trap trees (2 MMBF) per year for the next 2 years...Treatment of infested trap trees ranked in order of implementation from least cost to most cost are as follows: harvest by skidding (removal), harvest by helicopter (removal), chemical application of carbaryl (lethal trap tree), solar drying, burning. ...It is anticipated that spruce beetles will kill approximately 50% of the spruce volume over the course of the current outbreak if populations are left untreated. ...The area proposed for beetle containment in this document is only the inventoried roadless area portions of the commercial timber base plus the areas presently proposed by the Draft Forest Plan to be managed as semiprimitive recreation areas. Treatment for beetle outbreaks in the roaded portions of the Forest is being accomplished through standard timber salvage and harvest techniques, which does not accelerate the harvest...A secondary proposal...is to use carbaryl as a preventative spray for high valued spruce in specific campgrounds and guard stations. ...The interdisciplinary team eliminated the use of MCH (methylcyclohexenone) as a biological control method for prevention of beetle infestation because it is currently not registered with the EPA for operational use. ...I support implementation of a pilot project intended to gather needed data for registration of MCH." (USDA Forest Service, Payette National Forest 1986).

Thus the direction was decided that harvest and salvage would proceed, without acceleration, on those roaded commercial spruce lands and trap trees would be used to contain the infestation in the unroaded commerical spruce lands and semiprimitive recreation areas.

Williams (1986), in a memo to the supervisor of the Payette National Forest commented on the action:

> "...Applying measures to prevent a large scale spruce beetle infestation are only intended to buy time until the high-risk status of the commercial spruce timber base can be modified. If the food base--in this case large diameter old-growth spruce trees--remains, the potential for a large-scale infestation remains. Therefore if harvest of standing, green, susceptible trees is not accelerated, the potential for a large infestation remains, efforts to protect the commercial spruce type during the current outbreak are of little

Figure 4. Trees killed by spruce beetle according to aerial detection survey, Payette National Forest, Idaho 1986.



lasting benefit. Before spruce beetle management can be effectively addressed, spruce management must be addressed...."

In 1986 trend plots were established in various locations to follow the course of the infestation (Mocettini and Cahill 1989). Table 1 contains survey data from Mocettini and Cahill (1989) and Mocettini (1991) which portrays various results of the beetle infestation in these plots.

Table 1. Comparison of spruce attributes during a spruce beetle infestation, Payette National Forest, 1985-1990.

	Cumulative Mortality of Spruce > 12 inches Diameter (%)			Average Diameter of Live Spruce Trees (in)			
Location	1986	1988	1990	1985	1986	1988	1990
Upper Fisher Creek	1	82	89	13.3	13.0	9.4	9.6
Jackson Creek	12	64	80	15.8	15.0	12.0	10.2
Wilson Creek	0	11	95	13.2	13.2	13.8	9.4
Vance Creek	17	71	77	22.3	21.5	15.7	15.4
Hard Creek	0	11	80	20.9	20.9	19.8	13.4
Little French Creek	0	65	81	20.8	18.6	11.7	10.7
Marshall Lake	11	44	83	15.6	14.9	12.1	11.5

Salvage and removal of trap trees was planned for the Bear Creek, Middle Fork Weiser River, Elkhorn, Hershey Point, Kenneth Lake, Corral Creek, Lost Creek, Goose Creek, Clayburn Creek, Boulder Creek, Outlet Creek, Corduroy Creek, Josephine Creek, Wilson Creek and Poorman Creek drainages. Various problems with salvage and removal of trap trees surfaced. Since most spruce grows in wet areas, salvage or removal of trap trees was thought to be damaging to the site. This problem was especially noticeable in areas where trap trees were located and created in the winter. Snow obscurred the wet soil conditions prevalent during the summer when traps were to be removed. The obvious solution to this problem appeared to be trap tree placement before snowfall; however, trap trees, created in the fall, dried out and checked by the next summer rendering them unmerchantable as timber.

The timber market for spruce had weakened and salvage and removal of trap trees became less sure. Without a market outlet for timber, management options became limited. By late 1986 the market had again strengthened.

Late in 1986 forest managers realized the magnitude of the infestation far outweighed their abilities to manage the beetles. They prioritized the area of concern and elected to allow some infestations to run their course, even on commercial spruce lands.

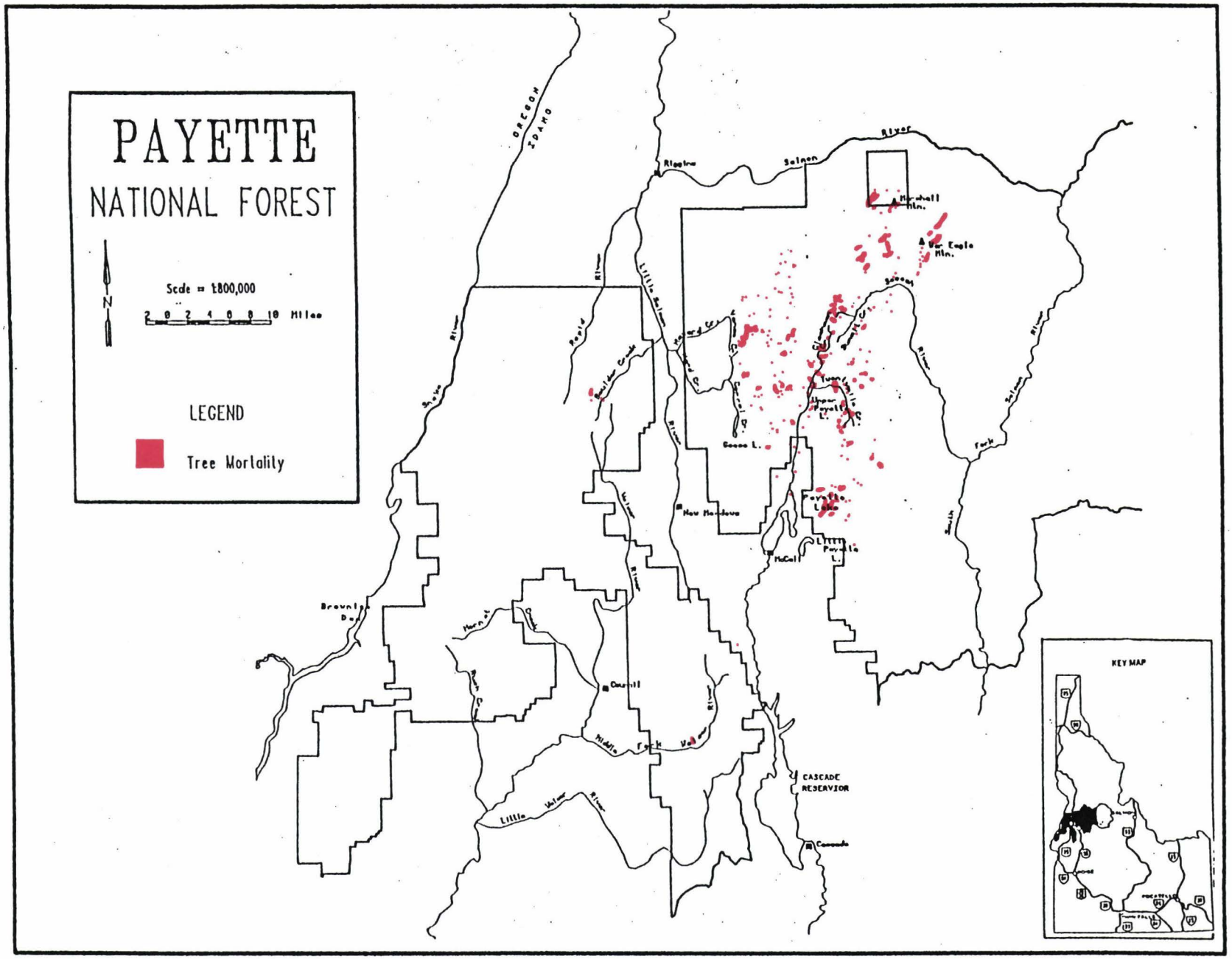
Further tests were begun using the insecticide carbaryl. Preliminary test results showed the beetle attacks and gallery lengths could be reduced significantly when the insecticide was applied preventively but questions remained regarding its toxicity to beetles emerging from trap trees.

1987

Aerial detection surveys in 1987 detected a growing infestation; over 15,800 trees were killed by spruce beetle. The infestation was located in the same general vicinity as the previous year (figure.5).

Forest managers modified management options because of continued concern for environmental hazards of salvage and trap tree removal in wet sites, the extent of the infestation, and cost of treatment of trap trees. Over 16.5 million board feet of spruce were salvaged for timber.

Figure 5. Trees killed by spruce beetle according to aerial detection survey, Payette National Forest, Idaho 1987.



Trap trees attracted beetles; however, in some areas, the trap trees may have attracted beetles from the surrounding unroaded spruce stands into the roaded commercial spruce stands. This was quite the opposite result as envisioned; thus, trap trees were to be used to a lesser extent.

In 1885, prior to the release of the Spruce Beetle Containment Project environmental document, approximately 300 trap trees were created in the Vance Creek drainage. These trap trees, and approximately 150 additional trees around the trap trees, were infested in 1986. The trap trees were not removed as planned because of access. In 1987, the concern was for the flight of beetles from these infested trees expected the next summer. Carbaryl was used as a preventive spray on hundreds of uninfested trees throughout the drainage prior to beetle flight in 1988. Trees were sprayed as high as could be reached but generally not higher than the basal 20 feet.

Tests using the insecticide carbaryl, to create lethal trap trees, were promising. Carbaryl treated spruces experienced significantly fewer spruce beetle attacks and less total adult gallery length than untreated checks. The results were the same regardless if the carbaryl was applied in the fall, six months prior to beetle flight, or spring just prior to beetle flight. These results agreed with those of Werner et al. (1986).

Another test installed in 1986, questioned if spruce beetle mortality could be increased following infestation of a trap tree if the tree were limbed, bucked and the bolts stood on end soon after attack. An evaluation of the procedure showed that there was almost a threefold reduction in numbers of beetles in the cut bolts. Despite the results, the procedure was not used in future management.

Two trap trees were created prior to the 1986 beetle flight. Soon after colonization, one tree was limbed and enveloped in black plastic sheeting. In August 1987 beetles were counted to ascertain differences in beetle survival. The plastic wrap treatment had no significant effect on beetle numbers.

The remedial effects of carbaryl were evaluated on overwintering populations of adult beetles in tree bases. Some trees were sprayed in the fall after the new beetles entered the tree bases to overwinter, some trees were sprayed in the spring just before beetles emerged from the overwintering sites. Evaluation showed the number of beetles emerging from the treated trees was no different than the number of beetles emerging from untreated trees.

Similarly, another test evaluated the preventive applications of carbaryl on new adult beetles seeking overwintering sites. Tree bases were treated with carbaryl to a height of several feet above soil line before beetles moved to the tree bases to overwinter. The following spring beetles were counted and, although fewer beetles were counted under the treated bark, the differences between treated trees and untreated checks were insignificant.

1988

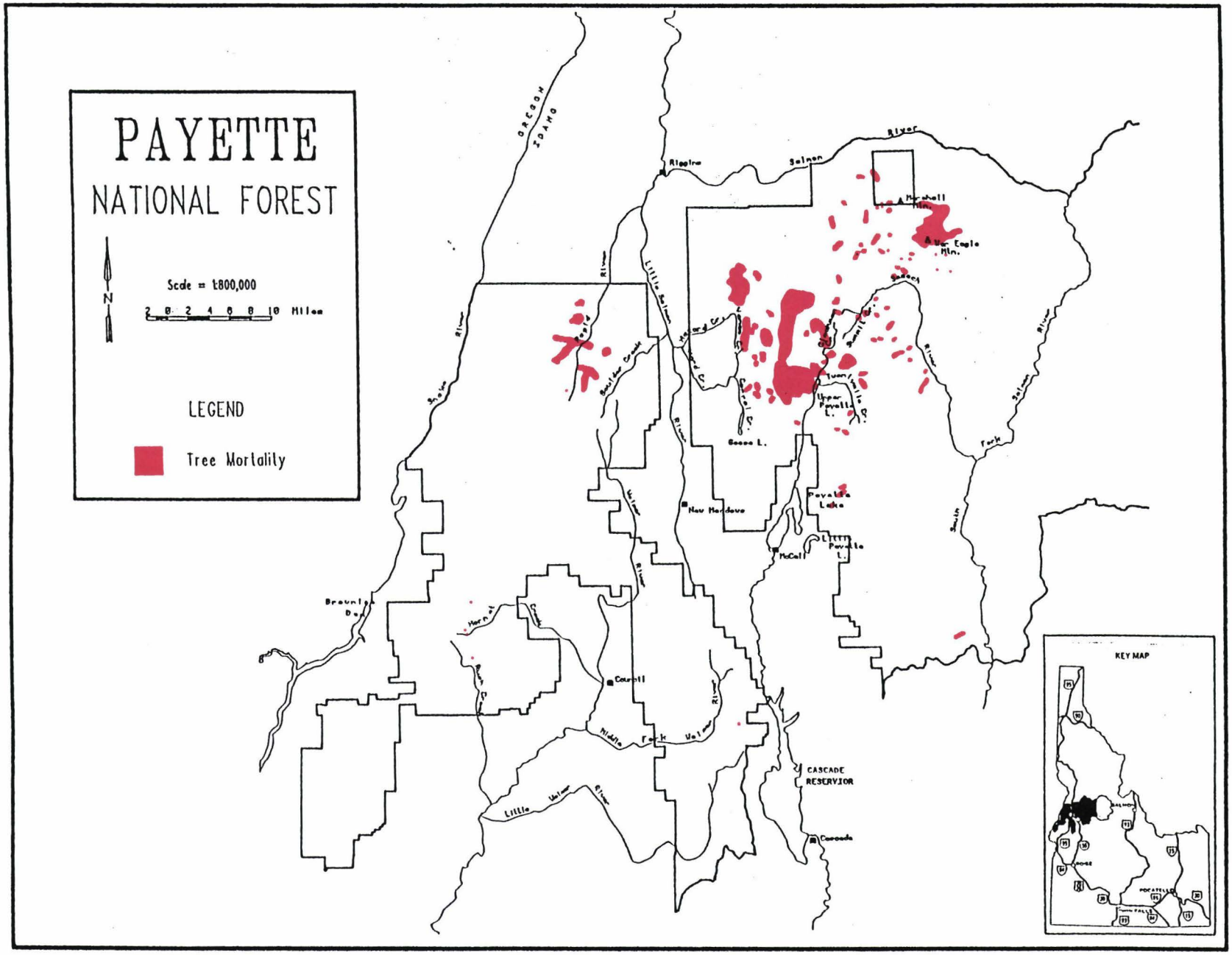
The number of trees killed by spruce beetle almost tripled to 44, 750 according to the 1988 aerial detection survey. The increase in activity was reflected in the survey by Mocettini and Cahill (1989) and is summarized in Table 1. Activity is displayed in figure 6.

An important biological change occurred in 1988. Until 1988 the spruce beetle generally had a 2-year life cycle. The summer of 1988 was long and hot and beetles that began development in the summer of 1988 accelerated their development, thus shortening their life cycle to 1-year. This likely meant that these beetles on a 1-year life cycle would mature and attack trees in the summer of 1989 along with those beetles which began development in 1987 and were on a 2-year life cycle.

This change in biology was important to management efforts - trap trees needed to be made available one year sooner, salvage needed to be completed sooner and the infestation was likely going to intensify greatly in 1989. Another 10.6 million board feet of spruce timber were salvaged but salvage and trap tree removal was complicated by the often wet, rocky or inaccessible sites from which spruce beetles continually attacked trees in the commercial spruce lands. Pheromone bait and treat began to replace the trap tree as the commonly used management option. The end result was much the same at a lesser cost to implement.

The protective spray treatments in Vance Creek appeared effective where the chemical was applied but, where the trees were not sprayed, attack was complete. One could easily see where the chemical application stopped up the bole by examining pattern of attacks. There were fewer attacks in the basal 15-20 feet of treated trees but attack density was much greater above that point.

Figure 6. Trees killed by spruce beetle according to aerial detection survey, Payette National Forest, Idaho 1988.



In late 1988 forest managers chose to continue management efforts but reassess their overall management strategy. Arrangements were made to address a worst case analysis in early 1989.

1989

Slightly more than 32,000 dead spruce trees were identified during the annual aerial detection survey. Activity was concentrated in the same general areas as years previous but now was generally bounded by Rapid River to the west (figure 7). Approximately 7.6 million board feet of spruce were removed as timber in an effort to capture timber value and manage the beetle infestation.

Although various management options were employed in an integrated strategy, as directed in the 1986 Spruce Beetle Containment Project, the containment objective was no longer viable. Spruce stands were being repeatedly entered for salvage of trees killed by spruce beetle. Consequently, the repeated salvage resulted in stand conversion to subalpine fir and loss of the more valuable spruce timber. The long term objectives which were stated in various Payette National Forest planning documents would not be attained if the infestation and management attempts persisted without change.

In early spring, forest managers began discussing different management alternatives after acknowledging that efforts to control the infestation to date were unsuccessful and that the infestation would likely continue. A proposal to accelerate the spruce harvest appeared most viable. A team was commissioned to explore the situation and recommend direction (Brown et al 1989).

Following several public meetings, and generation of issues regarding the spruce beetle situation, another team was assigned to prepare an environmental analysis. The proposal to be analyzed was to accelerate the harvest of threatened spruce via five timber sales. The team was to complete the project by fall; an ambitious assignment which was repeatedly delayed.

1990

As teams convened and conducted analyses, the beetle infestation continued. The changed life cycle was probably reflected in the 1990 aerial detection survey where a record 185,460 dead spruce were tallied. Activity again was concentrated in the same general area as that of previous years but extended to the east generally bounded by the Secesh River (figure 8). Evaluation of the beetle trend plots revealed that from 77-95% of the spruce >12 in. in diameter had been killed (Table 1) during the course of the infestation (Mocettini 1991). The remaining live spruce now ranged from 9.4 to 15.4 in. in diameter (Table 1). While awaiting new direction, salvage progresssed with 4.7 million board feet of dead spruce being removed. However, salvage was concentrated in timber management areas and the general containment objective of 1986 was discarded.

In July 1990, following completion of the environmental analyses, the Forest Supervisor of the Payette National Forest issued a decision to accelerate the harvest of spruce via four large timber sales to be sold in 1990 and 1991. For each sale the Forest Supervisor said, "The objective of this project is to accelerate the harvest and regeneration of Engelmann spruce before value is lost and to ensure future productivity of these project areas through reforestation." (USDA Forest Service Payette National Forest 1990). In total, approximately 22.3 million board feet of timber was proposed for harvest from approximately 1,140 acres.

1991

Aerial surveyors mapped only 23,800 dead spruce according to aerial detection surveys (figure 9). Perhaps the infestation had peaked in 1989 and was now declining because much of the susceptible host was killed. This certainly is supported by the survey results reported by Mocettini (1991). Salvage proceeded; 9.5 million board feet of spruce was harvested.

Harvest began on Corral Creek, Hazard Lake and Sater-Granite timber sales. These three timber sales were proposed as part of the accelerated harvest proposed in 1990 (USDA Forst Service Payette National Forest 1990).

In August 1991 the Payette National Forest supervisor issued another decision to further accelerate the harvest of spruce. This was in keeping with his previous decision in 1990. He stated, "The spruce beetle epidemic is a catastrophic condition that affects the Forest's ability to meet the desired future condition,

Figure 7. Trees killed by spruce beetle according to aerial detection survey, Payette National Forest, Idaho 1989.

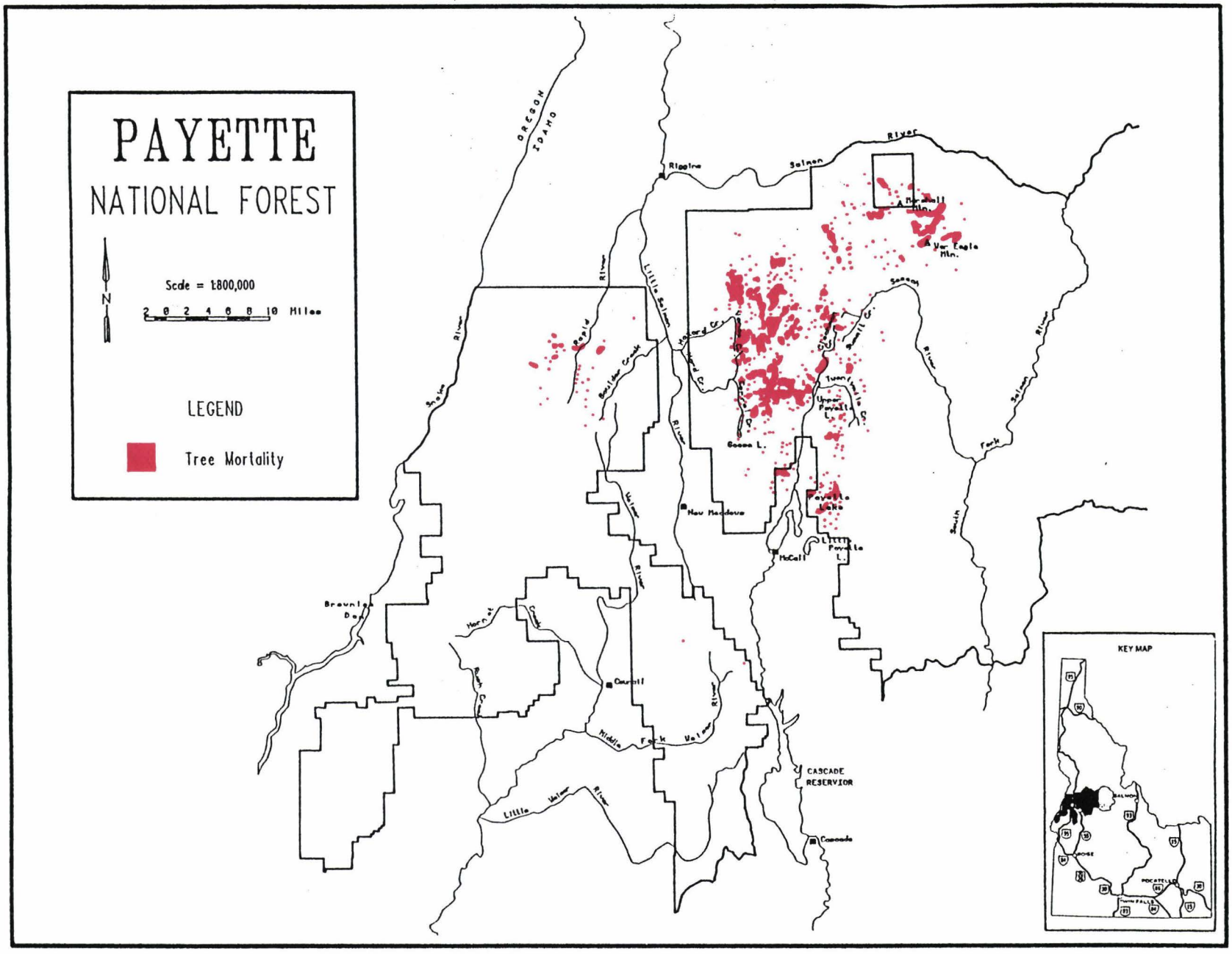


Figure 8. Trees killed by spruce beetle according to aerial detection survey, Payette National Forest, Idaho 1990.

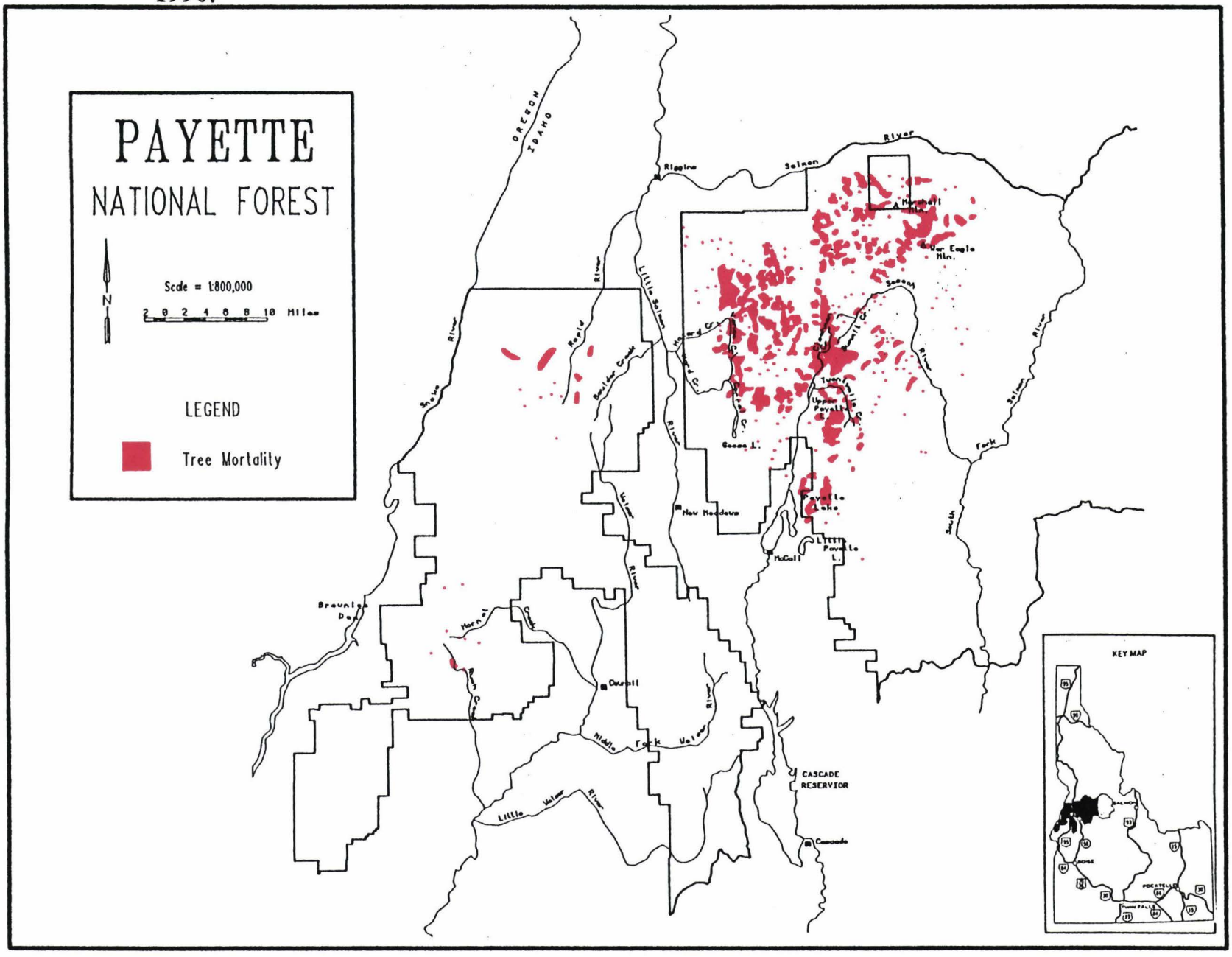
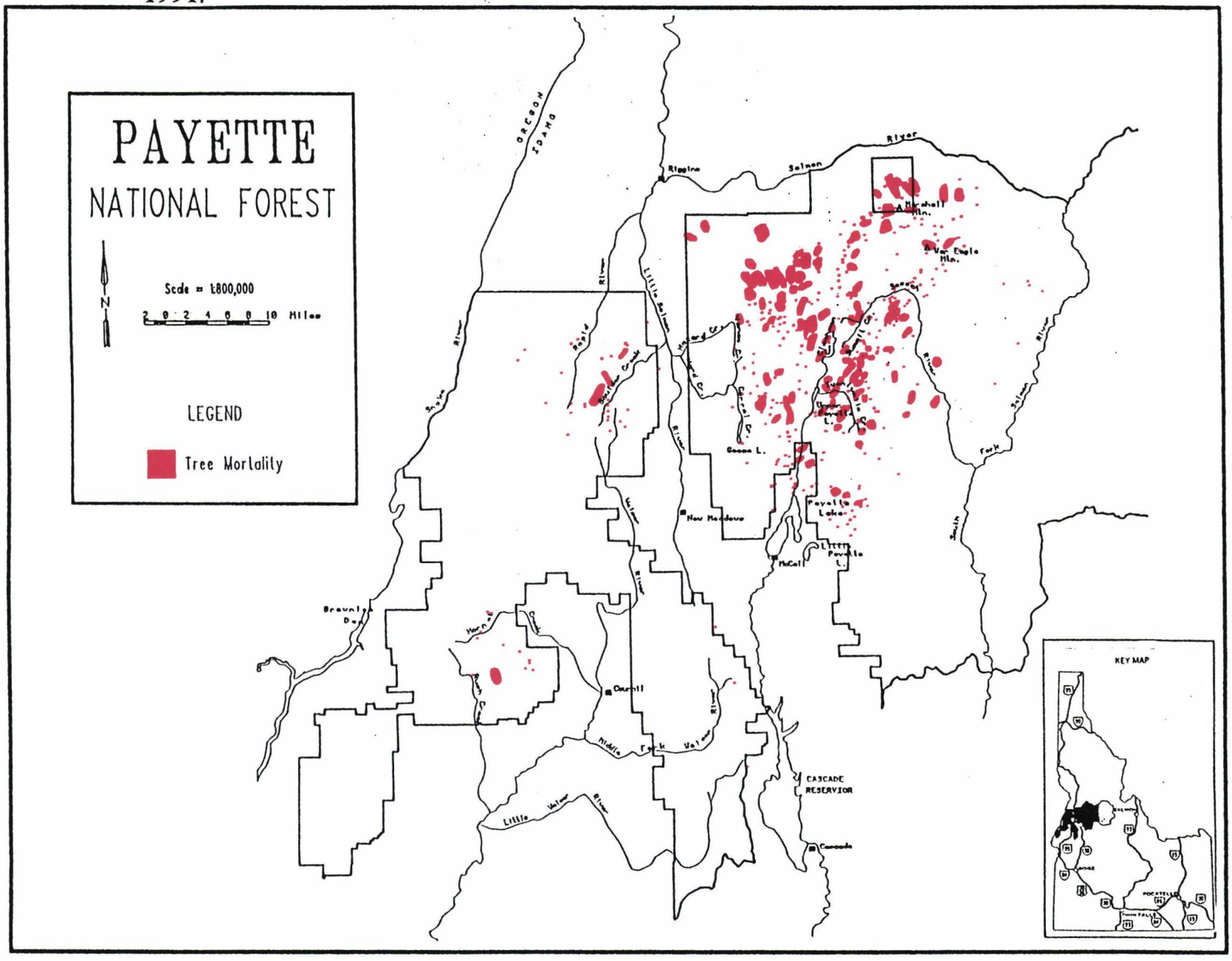


Figure 9. Trees killed by spruce beetle according to aerial detection survey, Payette National Forest, Idaho 1991.



Forest Plan...(USDA Forest Service Payette National Forest 1991). He continued, "There are two objectives for the proposed projects. The first objective is to accelerate the salvage of Engelmann spruce timber before its market value is lost or has greatly depreciated. The second objective is to reestablish these stands by planting Engelmann spruce and lodgepole pine seedlings to contribute to the accomplishment of Forest Plan long-term management goals." (USDA Forest Service Payette National Forest 1991). With this decision an additional approximate 31 million board feet of timber would be offered for commercial harvest from approximately 1,500 acres of forested lands.

1992

The infestation continued as 31,700 dead spruce were tallied during the annual aerial detection survey. Beetles continued to kill trees in the area generally bounded by Marshall Mountain and Payette Lake to the north and south respectively and Twentymile Creek on the east and Rapid River to the west (figure 10). Approximately 5.7 million board feet of spruce were salvaged.

Harvest began on the Hershey-Scribner and Brush Creek timber sales. Harvest was completed in 13 months on the Corral Creek timber sale. To date, this was the only completed accelerated harvest sale. It resulted in 4.89 million board feet of timber harvest; 3.45 million board feet of which were spruce.

1993

More than 35,240 spruce trees were killed by spruce beetle according to aerial detection surveys. Activity was evident throughout the spruce forest from the South Fork of the Salmon River on the east to the Little Salmon River on the west (figure 11). This represented an extension of activity into areas previously uninfested.

Harvest began on the Copet Creek and Hendricks Creek timber sales. These were the last of the accelerated harvest sales proposed in 1991 (USDA Forest Service Payette National Forest 1991).

On average, slightly over 12 months passed from the time the Payette National Forest Supervisor issued his decision to accelerate the spruce harvest until logging started on each sale. This time permitted the spruce beetle to complete another generation and kill additional trees. Therefore, large volumes of spruce were being removed as cull timber.

Harvests were completed on the Hershey-Scribner, Hazard Lake, Sater-Granite and Brush Creek timber sales. To date slightly over 49 million board feet of timber had been harvested of which 16.8 million board feet were spruce and 4.984 million board feet were cull timber.

Figure 10. Trees killed by spruce beetle according to aerial detection survey, Payette National Forest, Idaho, 1992.

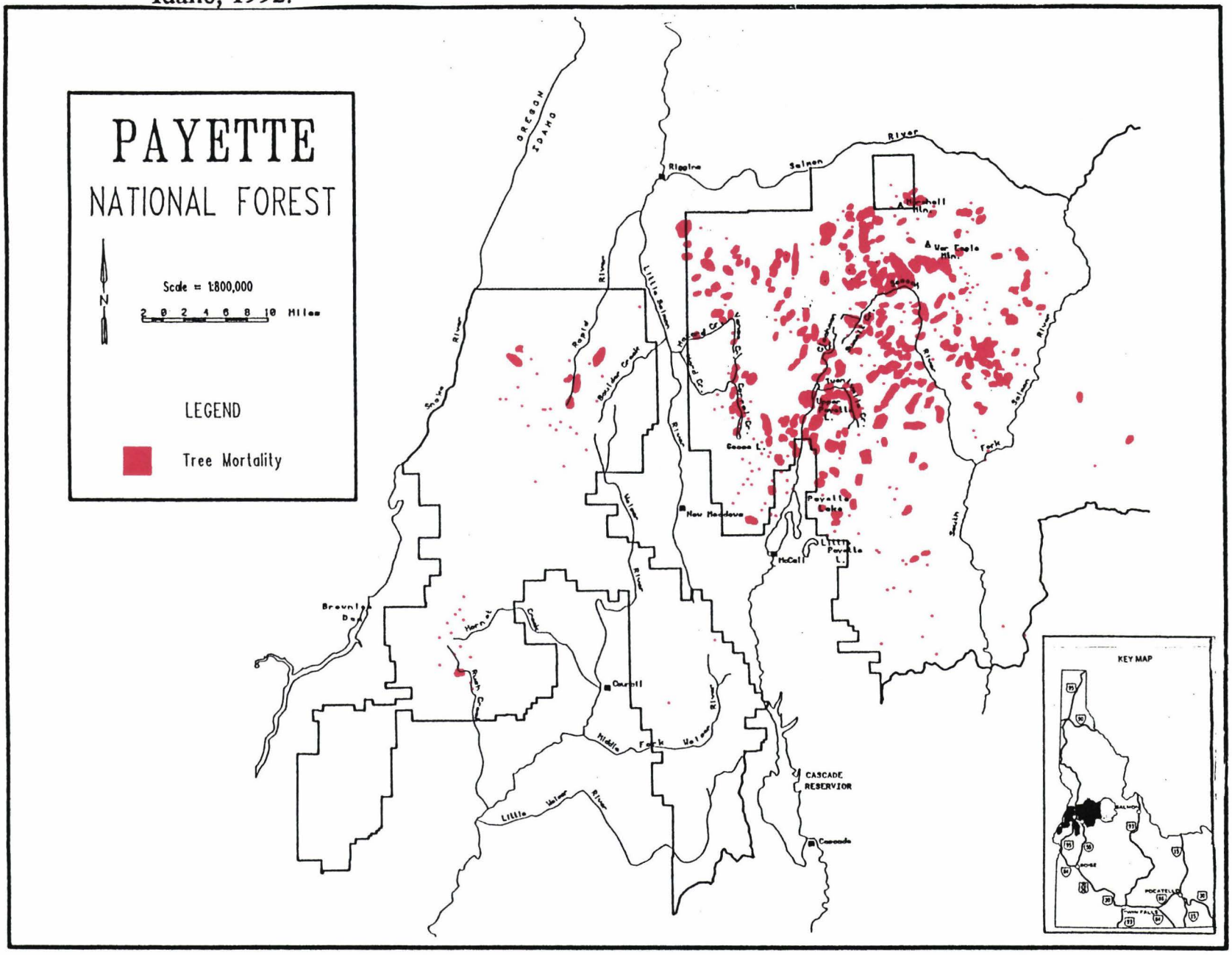
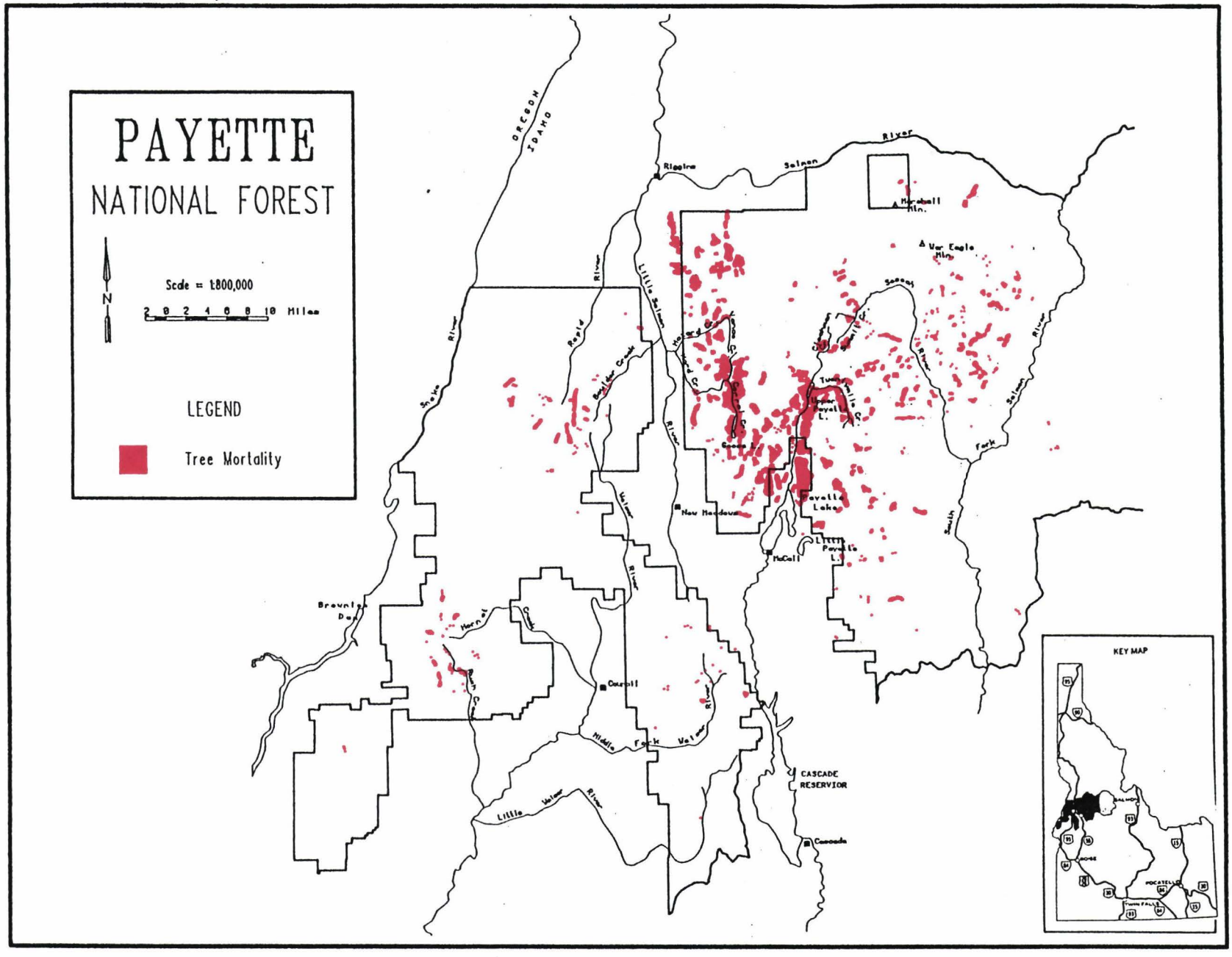


Figure 11. Trees killed by spruce beetle according to aerial detection survey, Payette National Forest, Idaho, 1993.



DISCUSSION

The spruce beetle is a native insect. It has coevolved with various species of spruce, and therefore is perfectly adapted to its environment. Likewise, spruce forests have sustained past spruce beetle infestations and, although forest conditions change, the forests persist.

Society places values on these forests and manages the forests to attain various objectives, whether they be for timber, wildlife habitat, water, or scenic beauty. It is because of society's objectives that we manage a forest, including its insect infestations.

Society's many diverse expectations provide the first of many constraints to forest management. Controvesy rages as groups disagree about appropriate management. While discussions continue and processes prescribed by law proceed; insects breed, seeds germinate and ecological processes advance, continually changing the situation.

The economic constraint imposed on forest management is also important. Certainly economics are an extension of society but deserve special comment because without economic support, forest management is impossible. Until society is prepared to directly or indirectly purchase a given forest commodity there is little incentive to fund management to produce that commodity. Examples of direct purchases include user fees and permit sales. An example of an indirect purchase is a bit more vague but includes allocation of public funds designated to operate a forest management program.

Finally the ecosystem's biotic and abiotic constraints must be recognized. These constraints are perhaps most important because they have obeyed unbreakable physical laws for so long, via evolutionary processes, that they are most powerful and ultimately will prevail. Examples of these constraints include population dynamics or ecological processes to name a few.

I want to apply hindsight to the Payette National Forest spruce beetle infestation noting how changes and constraints affected the course of events. These are my opinions but I think the bases for my opinions are supported throughout earlier sections of this report.

Let us look to the spruce forests of the Payette National Forest prior to the windthrow of the early 1980's. The spruce forests had grown to be dominated by large diameter spruce. The forest also had a history of previous spruce beetle activity. The stage was set for the events which were about to follow but could the infestation have been prevented? Without large scale cultural treatments, or forest fire, large diameter spruce would prevail. Society's expectations had already determined the management objectives. Some of these expectations were evident as management addressed roadless areas, riparian protection guidelines and the market value for spruce timber which all constrained cultural treatments and forest fire in the spruce forests.

The hazard posed by spruce beetle following windthrow of large diameter spruce is well documented. The spruce trees uprooted by wind in the early 1980's provided the opportunity for the spruce beetle infestation to grow. The infestation may have been contained if the spruce beetle populations infesting most of the windthrown spruce had been treated. Again, was treatment viable given the social, economic and biotic constraints? Probably not because of the nature of the event. Infested low-value windthrown spruce was widely distributed throughout the often inaccesible spruce forests making slavage unlikely. Funds were not available to send crews to treat the brood in the windthrown trees and decision-making processes and analyses prescribed by law involved precious time, effort and money.

Consider detection of the building beetle infestation. An epidemic was in place before its magnitude was recognized. Because of the beetles' life cycle and habits, spruce mortality was not generally detected by aerial detection surveys until 1985. Social and economic constraints were addressed by forest managers beginning in 1985 but the infestation had begun, progressing normally as programmed by milennia of evolutionary processes in the spruce forest.

The 1986 decision in the Spruce Beetle Containment Project was probably appropriate if one considers the constraints. General use of cultural, chemical and biological beetle management strategies were constrained by social, economic, biotic and abiotic factors. Williams (1986) statement that spruce management was needed was proven correct. Had the accelerated harvest decisions of 1989 and 1990 been made earlier perhaps more timber value would have been realized but where unmanaged, the beetle infestation would still run its course.

The beetles' changed life cycle in 1988 is worthy of discussion. Expectedly, change is constant in the forest ecosystem but society was not prepared to react to increased beetle activity. Plans, funding, staffing

and markets were tuned to the beetles' 2-year life cycle. More than doubling the spruce mortality and the processes, analyses and actions needed to manage the infestation were beyond comprehension.

CONCLUSION

The Payette National Forest sustained the largest spruce beetle infestation in recorded history. It started in the early 1980's and continues today. To date, over 350,000 trees have been killed by spruce beetles. The ecological and administrative results of this infestation will be significant long into the future.

The infestation, although unprecedented, was not unnatural and, without doubt, will occur again in spruce forests of North America. Forest managers will probably react similarly to those of the Payette National Forest during the next infestation because of the dilemma posed by society's expectations and forest dynamics.

Perhaps future infestations can be mitigated if cultural activities to reduce the chance of infestation are conducted prior to an outbreak. The cultural activities can only be conducted after society clearly defines the forest objectives with consideration of the ecosystem's biotic and abiotic constraints.

ACKNOWLEDGMENT

My sincere thanks to Dick Halsey and Phil Mocettini, Forest Pest Management, Boise Field Office for their assistance with compilation of data and figures. Donn Cahill, retired forest entomologist, Joe Fox, Payette National Forest, Rudy Verschoor and Erin Rohlman, McCall Ranger District, Payette National Forest, and Lynn Dixon, New Meadows Ranger District, Payette National Forest, assisted with research.

REFERENCES

Brown, B., L. Taylor, P. Arndt, and M. Dixon. 1989. Value analysis report - Spruce salvage program on the McMeadows District Payette National Forest. USDA Forest Service Payette National Forest, McCall, Idaho 19p.

Dyer, E. D. A. and J. A. Chapman. 1971. Attack by the spruce beetle induced by frontalin or billets with burrowing beetles. Canadian Forest.Service.Bi-Monthly Research Notes 27:10-11.

Holsten, E. H., R. W. Thier, and J. M. Schmid. 1991. The Spruce Beetle. USDA Forest Service. Forest Pest Leaflet 127. 12p.

Kline, L. N., R. F. Schmitz, J. A. Rudinsky, and M. M. Furniss. 1974. Repression of spruce beetle (Coleoptera) attraction by methylcyclohexenone in Idaho. Can. Ent. 106: 485-491.

Mocettini, P. J. and D. B. Cahill. 1989. Evaluation of spruce beetle population trends on the Payette National Forest , Idaho, 1985 - 1988. USDA Forest Service. Forest Pest Management. Intermountain Region. Report No. 89-2. 12p.

Mocettini, P. J. 1991. Spruce beetle population trend on the Payette National Forest, Idaho 1990 - An update. USDA Forest Service. Forest Pest Management. Intermountain Region. Report No. R4-91-05. 5p.

Nagel, R. H., D. McComb, and F. B. Knight. 1957. Trap tree method for controlling the Engelmann spruce beetle in Colorado. J. of Forestry 55(12):894-898.

Patterson, J. E. 1930. Control of the mountain pine beetle in lodgepole pine by the use of solar heat. USDA Tech. Bull. 195. 20p.

Schmid, J. M. and G. D. Amman. 1992. *Dendroctonus* beetles and old-growth forests in the Rockies. *in* Old-Growth Forests in the Southwest and Rocky Mountain Regions, Proceedings of a Workshop. USDA Forest Service General Technical Report RM-213.

Schmid, J. M. and R. H. Frye. 1977. Spruce Beetle in the Rockies. USDA Forest Service General Technical Report RM-49. 38p.

Shore, T. L., P. M. Hall, and T. F. Maher. 1990. Grid baiting of spruce stands with frontalin for pre-harvest containment of the spruce beetle, *Dendroctonus rufipennis* (Kirby) (Col. Scolytidae). J. Appl. Ent. 109:315-319.

Smith, D. M. 1962. The Practice of Silviculture. John Wiley & Sons. New York. 578p.

USDA Forest Service Payette National Forest. 1986. Spruce Beetle Containment Project, Payette National Forest Environmental Assessment. McCall Idaho. 23p.

USDA Forest Service Payette National Forest. 1990. Decision Notices and Finding of No Significance for Sater-Granite Salvage, Corral Creek Salvage, Hazard Lakes Salvage, Hershey-Scribner Salvage Timber Sales. McCall Idaho. 44p.

USDA Forest Service Payette National Forest. 1991. Record of Decision for the Accelerated Engelmann Spruce Harvest for Brush Creek, Hendricks Creek, and Copet Creek Salvage Timber Sales. McCall, Idaho. 31p.

Werner, R. A. F., F. L. Hastings, E. H. Holsten, and A. S. Jones. 1986. Carbaryl and lindane protect white spruce from attack by spruce beetles (Coleoptera: Scolytidae) for three growing seasons. J. Econ. Entomol. 79:1121-1124.

Williams, R. E. 1986. FPM review of 1/22/86 spruce beetle scoping document. Memo to Supervisor, Payette National Forest. File designation 3400 dated February 12, 1986. Boise ID.